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**The Impact of Accuracy and Effort
Feedback and Goals on Adaptive
Decision Behavior**

Elizabeth H. Creyer¹, James R. Bettman²
and John W. Payne²

February 1989

Center for Decision Studies

Center for Decision Studies
The Fuqua School of Business
Duke University
Durham, North Carolina 27706



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19 ABSTRACT (Continue on reverse if necessary and identify by block number) This paper examines the impact of accuracy and effort feedback on decision processes. The effects of emphasizing either a goal of maximizing accuracy relative to effort or minimizing effort relative to accuracy are also considered. Feedback on the accuracy of decisions leads to more normative like processing information and improved performance only in the most difficult problems, i.e., decisions with low dispersion in attribute weights. Explicit effort feedback has almost no impact on processing or performance. The impact of the goal manipulation on decision processes was found to be consistent with the shift in strategies predicted by an effort/accuracy model of strategy selection. In particular, a goal of emphasizing accuracy led to more normative-like processing, while emphasis on effort led to less extensive, more selective, and more attribute-based processing and poorer performance. These results provide perhaps the clearest evidence to date of the effect of goals on processing differences. Complex interactive relationships between types of feedback and goal structures suggest the need for additional study.					
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Over the past two decades, a number of strategies used by people to evaluate decision alternatives have been identified (Svenson, 1979; Abelson and Levi, 1985). Some of the strategies involve the consideration of all the relevant decision information in a normative fashion. For example, the Weighted Additive (WADD) rule considers the values of each alternative on all the relevant attributes and considers all the relative importances (weights or probabilities) of the attributes (outcomes) to the decision maker in a compensatory fashion. Other strategies identified involve the selective processing of much less information and are noncompensatory. For example, the lexicographic choice rule (Tversky, 1969) simply chooses the alternative which is best on the most important attribute, ignoring much of the potentially relevant problem information.

A second major finding from years of decision research is that the same individual will often employ diverse information processing strategies in making a decision, contingent on task demands (Einhorn and Hogarth, 1981; Payne, 1982; Hammond, 1986). For example, when faced with a decision problem involving only two or three alternatives, people generally use more compensatory types of strategies. When faced with more complex (multialternative) decision tasks, people tend to use noncompensatory strategies such as elimination-by-aspects (EBA) (Tversky, 1972).

Given the substantial evidence for contingent decision behavior, a natural question is why decision makers, given a particular task, select one particular decision strategy instead of another. The most frequently advocated approach to answering that question is to assume that the selection among decision strategies is, in part, a function of the strategy's accuracy and the strategy's effort (i.e., its demand for mental resources) (Beach and



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Mitchell, 1978; Russo and Doshier, 1983; Johnson and Payne, 1985). The effort-accuracy framework provides a way of explaining contingent decision behavior, since the effort and accuracy associated with various strategies are likely to vary across problems.

Recently, Payne, Bettman, and Johnson (1988) examined the role of effort and accuracy considerations in the adaptive use of decision strategies. They were concerned with the extent to which a decision maker chooses strategies that are relatively efficient in terms of effort and accuracy as task and context demands are varied. Monte-Carlo simulation was used to examine the impact of variation in problem size, the presence or absence of time pressure, the presence or absence of dominated alternatives, and dispersion in probabilities or attribute weights¹ on the accuracy and effort of a variety of choice heuristics. Choice heuristics which approximated the accuracy of normative procedures while requiring substantially less effort were identified, indicating that heuristics can provide an efficient form of decision processing (Thorngate, 1980). However, no single heuristic did well across all the task and context conditions studied by Payne et. al. (1988). The implication is that a decision maker striving to maintain a high level of accuracy with a minimum of effort would have to adaptively use a variety of heuristics.

Payne et. al. (1988) next investigated whether the actual decision behavior exhibited by subjects was consistent with the processing patterns identified by the Monte-Carlo simulations. The results provided strong evidence of adaptivity in decision making. Generally, the subjects changed processing strategies in ways that the simulation indicated were appropriate given changes in the structure of the decision tasks. For example, when the dispersion in probabilities (weights) was high rather than low, subjects

generally acquired less information, spent less time per acquisition, were more selective regarding which information was examined, and processed information more by attribute than by alternative. Payne et. al. suggested that the shifts in processing reflected a shift in strategies from a compensatory type strategy in the low dispersion condition to a lexicographic or EBA type of strategy in the high dispersion condition.

Although clear evidence of adaptivity was obtained, several unresolved issues regarding such adaptive selection remain. For instance, the evidence reported in Payne, Bettman, and Johnson (1988) suggests that people were learning to adapt their decision strategies to changes in task and context. Yet in none of their experiments did Payne et. al. provide their subjects with explicit accuracy or outcome feedback. In such situations, how might an individual learn when and how to change decision strategies? In addition, if individuals make effort-accuracy tradeoffs in strategy selection, then the strategies used should vary if the relative weight placed on effort versus accuracy is changed. Payne et. al. did not examine this aspect of adaptation. These two major issues are examined in the present study: 1) How decision makers learn to adapt, and 2) How the relative weight placed on effort versus accuracy affects decision processes.

Learning to Adapt

For an individual to adapt decision strategies to a particular decision task, he or she must have at least some vague ideas about the degree of effort and accuracy characterizing his or her decision process. Payne et. al. speculate that process feedback (Anzai and Simon, 1979) could easily provide information on the effort involved in using a strategy. Process feedback is information about the course of one's own decision processes. In the course of solving a decision problem, an individual probably has a fairly rich data base

available about how effortful and/or difficult he or she is finding the decision. In contrast, gaining information on accuracy from process feedback in these experiments would seem more problematic. One does not know exactly whether the final decision is a good one or not.

A self-generated notion of accuracy is possible to some degree if we assume that individuals have general knowledge about the properties of a reasonable strategy, at least for some decision tasks. For example, decision makers might believe that a "good" strategy involves first looking at the most important information for all alternatives, and then looking at other information as desired or as time allows (Payne, Bettman, and Johnson (1988) report data supporting this notion). An individual could then observe how well his or her choice process as executed matched this general notion of a "good" strategy. For example, if time ran out before some important information could be considered, then the individual might decide that the process should be changed. Such use of process feedback to assess accuracy is similar to ideas of Reder (1987), who suggests that people generate "feelings of knowing" about the quality of their performance during the course of problem solving.

The present study examines how decision makers may learn to adapt when presented with explicit accuracy feedback and/or explicit effort feedback. The notions about process feedback outlined above suggest some interesting hypotheses in this situation. For example, the presence of explicit accuracy feedback should only improve the quality of decisions for problems where individuals do not have strong notions of a "good" strategy. Thus, the effects of accuracy feedback should vary across decision tasks. For instance, the general notion of a "good" strategy outlined above (i.e., look at the most important information first) is less easy to execute when faced with problems

involving low dispersion, since one cannot easily be selective. Payne, Bettman, and Johnson (1988) also found that low dispersion problems took longer to solve. In addition, subjects report when asked that decisions with low dispersion are more difficult and that they have less confidence in their decisions when dispersion is low.² Given these perceptions, process feedback seems less likely to suffice. Hence, we predict that explicit accuracy feedback will have greater effects on low dispersion decision problems.

The discussion of process feedback above implies that individuals are able to generate fairly accurate notions about their own effort levels. Therefore, the addition of explicit effort feedback should provide little additional information which might affect individuals' decision processes. While effort feedback may not provide any additional information to the decision maker, both effort and accuracy may exert motivational influences on the choice process. Such influences are considered below. It should be noted, however, that although we have separated the information provided by feedback from its motivational effects in this discussion, informational and motivational effects are extremely difficult to distinguish, both empirically and theoretically (Tetlock and Levi, 1982). We use the terms motivational and informational for convenience in describing our thinking and hypotheses; however, our focus is on the overall pattern of results we obtain, not on distinguishing these two types of effects empirically.

Weighting Effort versus Accuracy

When deciding how to decide, the effort-accuracy framework assumes that a decision maker evaluates the costs (i.e., effort) and benefits (i.e., accuracy) of the various strategies that are known to him or her and selects that strategy which is in some sense best for the environment. Such a framework implies that strategy selection will be guided by the relative

salience of effort and accuracy in the decision environment. A second purpose of the present study is to directly examine how decision processing varies as the goals and incentives in a decision environment are changed to shift the relative emphasis on accuracy and effort. We hypothesize that a goal emphasizing accuracy to a greater extent will lead to more normative types of processing and improved accuracy. A goal emphasizing effort minimization to a greater extent is expected to lead to more use of heuristics like elimination-by-aspects or the lexicographic rule.

As noted above, explicit accuracy feedback and explicit effort feedback could have motivational implications, in addition to providing information about the efficiency of decision strategies. For example, the availability of explicit effort feedback might increase the saliency of the effort expended during the choice process. Similarly, explicit accuracy feedback could enhance the concern with accuracy. We hypothesize that these motivational effects of feedback will interact with the goal of the decision maker. In particular, making effort more salient by providing effort feedback might lead to more heuristic processing and poorer performance when the goal is to minimize effort; however, when the goal is to maximize accuracy, highlighting effort via effort feedback might make the decision maker work harder and could improve performance. Subjects often believe that greater effort does lead to better performance (Yates & Kulick, 1977). Likewise, accuracy feedback may interact with the decision maker's goal. If the goal is to maximize accuracy, the decision maker may use accuracy feedback to the best of his or her ability in order to try to process more normatively and improve performance; however, providing accuracy feedback may have little effect on the decision maker if the goal is to minimize effort.

To summarize, the purposes of this paper are to 1) examine the impact of feedback on accuracy and effort on the adaptive use of decision strategies; and 2) to investigate how changes in goals influence the use of various decision strategies. We hypothesize the following:

1) Accuracy feedback will have its greatest impact when decision makers are faced with more difficult problems, such as those where the dispersion in weights (probabilities) is low. The impact of accuracy feedback will be to increase the use of more normative decision strategies like the weighted additive rule. Such strategies are characterized by a substantial amount of processing; an amount of processing that is not selective but rather is consistent across alternatives and attributes, indicating more compensatory processes (Payne, 1976); and processing that is alternative-based rather than attribute-based (that is, multiple items of information about a single alternative are processed before any information about another alternative is processed).

2) The availability of effort feedback will have little direct impact on decision behavior.

3) A goal statement that emphasizes accuracy more than effort will lead to the use of more normative strategies like WADD. In contrast, a goal statement that emphasizes effort savings more than accuracy will lead to the use of strategies like the lexicographic rule or elimination-by-aspects. Such strategies are characterized by a smaller amount of processing, processing that is selective across attributes and/or alternatives, and processing that is attribute-based. This last prediction is based on the suggestion by Tversky (1969) and by Russo and Doshier (1983) that attribute-based processing is cognitively easier.

4) Effort and accuracy feedback will interact with the goal of the decision maker to jointly determine performance and type of processing. Both effort and accuracy feedback will lead to more normative processing and better performance when the goal is to maximize accuracy. When the goal is to minimize effort, however, effort feedback will foster more heuristic processing and decreased performance, while accuracy feedback will have little effect.

Method

Overview

Subjects used a computer-based information acquisition system (Johnson, Payne, Schkade, and Bettman, 1986) to acquire information and make decisions among 32 sets of multiattribute nonrisky alternatives. The subjects' task was to select the alternative in each set that they thought was best overall. Each set contained four alternatives defined by six attributes. The sets varied within subjects with respect to 1) the dispersion of the weights provided for the attributes (high or low) and 2) the explicit goal of the decision maker for the set (minimize effort or maximize accuracy). The between-subject factors were the presence or absence of 1) effort feedback and 2) accuracy feedback.

Subjects

Eighty-one undergraduates at a large, northeastern university enrolled in an introductory marketing course served as subjects. Participation in the experiment earned credit towards fulfillment of a course requirement. In order to encourage the subjects to do their best, they were told that they were eligible to enter a \$100 lottery if their performance exceeded a standard. Subjects were told that an index of overall performance would be developed based upon the time taken and the accuracy achieved for each trial.

Subjects were instructed that for trials when the goal was to minimize effort, time taken would be given a weight of three and accuracy a weight of one. On trials where the goal was to maximize accuracy, time taken would receive a weight of one and accuracy a weight of three. Thus, both accuracy and effort (time taken) mattered for all trial; we tried to manipulate the relative importance of those two issues. However, in all cases choosing an accurate response quickly would lead to a higher index of overall performance.

Subjects were told that these scores would be aggregated for all 32 trials, and that subjects whose index met a minimum requirement (which was not further specified) would be eligible for the lottery. In fact, all subjects were entered into the lottery.

Stimuli

The stimuli were sets of four nonrisky options with six attributes. The values of the attributes were single digits ranging from 2 (least preferred) to 9 (most preferred). A set of weights for the attributes was also presented, with the weights constrained to sum to 100. The alternatives were simply labeled Alternative A through Alternative D, with attributes labeled simply Attributes 1 through Attribute 6.

Eight sets of low dispersion in weights options and eight sets of high dispersion options were generated, with the possibility of dominated options allowed in all sets. To illustrate, one low dispersion set of alternatives had weights of 13, 20, 13, 28, 12, and 14 for the six attributes. One high dispersion set of options had weights of 70, 12, 3, 4, 5, and 6.

Each of these 16 sets of options was presented to subjects twice in order to manipulate the subject's goal for the decision. For one presentation, the subject was instructed that minimization of the effort used to decide among the alternatives was relatively more important. For the other

presentation, subjects were told that the maximization of the accuracy of their choice was relatively more important. Thus, each subject received 32 decision problems (2 dispersion conditions x 2 goal conditions x 8 replications). The use of a within-subjects design for dispersion and goal provides a strong test of adaptivity, since subjects would be expected to switch strategies from one decision problem to the next.

The first 16 problems presented to each subject contained four sets corresponding to each of the four dispersion x goal combinations, as did the second 16 problems. Within each block of 16 problems, the problem sets were randomly arranged, with the same random order for each subject. A complete experimental session took from 40-60 minutes for each subject.

Information Acquisition Methodology

Information acquisitions, response times, and choices were monitored using a software system called Mouselab (Johnson, Payne, Schkade, & Bettman, 1986). This system uses an IBM personal computer, or equivalent, equipped with a "mouse" for moving a cursor around the display screen of the computer. The stimuli are presented on the display in the form of a matrix of available information. The first row of boxes contained information about the weights for the six attributes. The next four rows of boxes contained information about the values associated with the different outcomes for each alternative, respectively. At the bottom of the screen were four boxes that were used to indicate which alternative was most preferred.

When a set of alternatives first appears on the screen, the values of the attributes and weights are "hidden" behind the labeled boxes. To open a particular box and examine the information, the subject has to move the cursor into the box. The box immediately opens and remains open until the cursor is

moved out of the box. Only one box can be open at a time. Subjects could acquire as much or as little information as they desired.

The Mouselab program records the order in which boxes are opened, the amount of time boxes are open, the chosen option, and the total elapsed time since the display first appeared on the screen. Response times are recorded to an accuracy of 1/60th of a second.

Feedback Manipulations

Accuracy Feedback. One between-subjects factor was the presence or absence of explicit accuracy feedback. Before defining the form of such feedback, we must first consider how to define subjects' accuracy levels. While accuracy of choice can be defined in many ways (e.g., not selecting dominated alternatives or avoiding intransitive patterns of preferences), the compensatory weighted additive rule is often used as a criterion for decision effectiveness in multiattribute choice (Zakay & Wooler, 1984). The weighted additive rule is a normative procedure in that all information is processed and tradeoffs reflecting the decision maker's values are incorporated into the decision. A measure of the accuracy of a decision can be derived by comparing the weighted additive value for the alternative selected from a set to the best and worst possible values for that set:

$$\text{Relative Accuracy} = \frac{\text{Weighted Additive Value}_{\text{Choice}} - \text{Weighted Additive Value}_{\text{Worst}}}{\text{Weighted Additive Value}_{\text{Best}} - \text{Weighted Additive Value}_{\text{Worst}}}$$

This measure is bounded by a value of 1 if the option with the highest weighted additive value is selected and a value of 0 if the option with the worst weighted additive value is chosen. It provides a measure of the relative improvement of a choice over the worst possible choice. For further discussion of this and other measures of accuracy, see Johnson & Payne (1985) or Payne, Bettman, & Johnson (1988).

This measure was used to provide accuracy feedback to subjects via Mouselab. For each choice set, the relative accuracy score corresponding to each option was computed. After the subject had made a choice for a problem set, a scale ranging from 0 to 1 appeared on the screen. The letters A through D were positioned on the scale to correspond to their relative accuracy scores. For example, if the weighted additive values for alternatives A to D were 125, 200, 150, and 100, then the relative accuracy scores would be .25, 1, .5, and 0 respectively. Alternative D would be placed above the left end of the scale, Alternative A would be one-quarter of the way toward the right end of the scale, Alternative C would be above the midpoint of the scale, and Alternative B would be above the right end of the scale.

Subjects could see the relative positioning of the alternatives and thus receive visual feedback. In addition, subjects could move the mouse along the scale to correspond to the letter for any alternative. The exact relative accuracy score for that alternative would then be displayed.

Effort Feedback. The second between-subjects factor was the presence or absence of explicit effort feedback. For subjects in the effort feedback condition, a clock was displayed in the top left corner of the screen for each set of alternatives presented. The clock, initially a completely shaded circle, began to disappear when the subject started to gather information about the alternatives and stopped when the subject selected an alternative. The extent to which the circle was no longer shaded was an indication of the amount of time used by the subject to decide among the alternatives. The results from a pilot study suggested that giving the clock 200 seconds to fully disappear provided distinguishable effort feedback while enabling subjects to decide among the alternatives before the time expired. Thus, there was no time constraint; subjects had enough time to easily finish each

trial. However, the feedback did provide a potential indicator of the effort expanded.³

Procedure

Subjects were told that the purpose of the experiment was to understand how people make decisions and that they should select the option they thought best from each set. Subjects were randomly assigned to one of the four between-subject experimental conditions defined by the presence or absence of accuracy and effort feedback. Each subject was also informed that if his or her performance exceeded the standard described above, he or she would be eligible for a lottery with a prize of \$100.

Each subject was run individually. First the subject was instructed on the Mouselab system and allowed to practice its use on a series of tasks unrelated to the present study. Subjects were then presented with two practice problems and the 32 decision problems. The complete design was a two between-subject factors (accuracy feedback absent or present, effort feedback absent or present), two within-subject factors (dispersion low or high, goal of minimizing effort or maximizing accuracy) complete factorial with eight replicates for each of the four combinations of the within-subject factors.

Dependent Measures

Information acquisition and decision behavior can be characterized in many ways. One can examine the amount and sequence of information acquired and the time spent acquiring information (Klayman, 1983). We consider six measures of aspects of decision processing to examine the hypotheses. One important aspect is the total amount of processing. One measure of amount is the total number of times information boxes were opened for a particular decision, denoted acquisitions (ACQ). A second measure related to the amount

of processing effort is the total amount of time spent examining information in the boxes (BOXTIME).

The next measures reflect the relative attention devoted to specific types of information, and hence are relevant to characterizing selectivity in processing. One measure, denoted (PTMI), is the proportion of the total time acquiring information that was spent in boxes involving the most important attribute of a particular decision problem. The attribute with the largest weight was defined to be the most important attribute.

The next two measures are the variances in the proportions of time spent on each alternative (VAR-ALTER) and on each attribute (VAR-ATTRIB). Such variances are related to selectivity. More compensatory decision rules such as weighted additive imply a pattern of information acquisition that is consistent (low in variance) across alternatives and attributes; in contrast, noncompensatory strategies such as EBA or lexicographic imply more variance in processing.

A final measure of processing characterizes the sequence of information acquisitions relating to attribute values. Given the acquisition of a particular piece of information, two particularly relevant cases for the next piece of information acquired involve the same alternative but different attribute (an alternative-based, holistic, or a Type 1 transition), and the same attribute but a different alternative (an attribute-based, dimensional, or Type 2 transition). A simple measure of the relative amount of alternative-based (Type 1) and attribute-based (Type 2) transitions is provided by calculating the number of Type 1 transitions minus the number of Type 2 transitions divided by the sum of Type 1 and Type 2 transitions (Payne, 1976). This measure of the relative use of alternative-based versus attribute-based processing, denoted PATTERN, ranges from a value of -1.0 to

+1.0. A more positive number indicates relatively more alternative-based processing, while a more negative number indicates relatively more attribute-based processing.

In addition to these six measures of processing, a measure of relative accuracy, defined as above in terms of the worst and best choices for each set, was developed and denoted GAIN.

These measures can be related directly to the hypotheses outlined earlier. The manipulations that should lead to more normative patterns of processing, such as the presence of accuracy feedback for low dispersion problems or a goal emphasizing accuracy, for example, should lead to higher values of PATTERN (more alternative-based processing); lower values of VAR-ALTER and VAR-ATTRIB (less selectivity); and lower values of PTMI (less focus on the most important attribute). In addition, there should be more acquisitions (ACQ) and greater BOXTIME (more processing effort). Finally, GAIN should be higher. Conditions leading to less normative processing would show the opposite pattern of results.

Results

Overview

The main focus in the results concerns how subjects adapt to the manipulations of feedback and goal. However, we will also briefly present the results for dispersion to ensure that the prior results of Payne, Bettman, and Johnson (1988) are replicated. Effects are examined for the four main types of dependent measures outlined above: amount of processing, selectivity in processing, pattern of processing, and relative accuracy.

Multivariate Analysis

Given the likely correlations among the various dependent measures, the data were first analyzed using a multivariate analysis of variance with two

within-subject factors (dispersion and goal) and two between-subject factors (accuracy feedback and effort feedback). The analysis included the six process measures described above plus the measure of relative accuracy (GAIN). Means for these measures are presented in Table 1.⁴

There were main effects of goal ($F(7,2368) = 31.8, p < .0001$) and dispersion ($F(7,2368) = 32.55, p < .0001$), but no main effects of accuracy feedback ($F(7,71) = 1.01, ns$) or effort feedback ($F(7,71) = .99, ns$). The two-way interactions of accuracy feedback by goal ($F(7,2368) = 4.52, p < .0001$), effort feedback by goal ($F(7,2368) = 2.46, p < .02$), accuracy feedback by dispersion ($F(7,2368) = 4.95, p < .0001$), and goal by dispersion ($F(7,2368) = 3.41, p < .0002$) were significant. The other two-way interactions, accuracy feedback by effort feedback ($F(7,71) = .66, ns$) and effort feedback by dispersion ($F(7,2368) = .67, ns$), were not significant. Finally, there was one significant three-way interaction involving accuracy feedback, effort feedback, and goal ($F(7,2368) = 2.98, p < .004$). The other three-way interactions and the four-way interaction were not significant.

 Insert Table 1 about here

Univariate Analyses

To more completely characterize the effects of dispersion, accuracy feedback, effort feedback, and goal, separate univariate analyses of variance were conducted for each of the dependent measures. The results presented in Table 1 will first be discussed for dispersion, then accuracy feedback, then effort feedback, and then for goal. Hypothesized interactions will be discussed where appropriate. Within each section, the results are presented for the amount of processing (ACQ and BOXTIME), then for the selectivity

Table 1

Summary of Process Measures and GAIN as a Function of Accuracy Feedback, Effort Feedback, Dispersion, and Goal

Minimize Effort Goal								
Dispersion:	<u>Low</u>				<u>High</u>			
Accuracy Feedback:	<u>No</u>		<u>Yes</u>		<u>No</u>		<u>Yes</u>	
Effort Feedback:	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
ACQ	17.0	22.0	29.1	24.7	15.1	22.2	25.3	21.1
BOXTIME	8.6	11.0	15.8	12.0	7.7	11.4	12.9	10.0
PTMI	.36	.39	.37	.36	.43	.47	.43	.46
VAR-ALTER	.09	.10	.07	.09	.10	.11	.08	.09
VAR-ATTRIB	.16	.13	.13	.12	.21	.19	.18	.18
PATTERN	-.59	-.52	-.35	-.28	-.72	-.62	-.55	-.42
GAIN	.58	.61	.74	.61	.74	.78	.80	.72

Maximize Accuracy Goal								
Dispersion:	<u>Low</u>				<u>High</u>			
Accuracy Feedback:	<u>No</u>		<u>Yes</u>		<u>No</u>		<u>Yes</u>	
Effort Feedback:	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
ACQ	25.8	27.0	41.3	37.8	23.6	26.8	34.7	31.4
BOXTIME	15.2	16.2	25.9	20.6	13.5	14.2	20.6	16.5
PTMI	.40	.38	.32	.32	.42	.42	.36	.34
VAR-ALTER	.09	.09	.06	.09	.09	.08	.06	.10
VAR-ATTRIB	.15	.13	.10	.09	.20	.19	.12	.11
PATTERN	-.49	-.42	-.19	-.16	-.53	-.52	-.34	-.20
GAIN	.61	.67	.76	.75	.81	.80	.78	.84

measures (PTMI, VAR-ALTER, and VAR-ATTRIB), for the PATTERN measure, and finally for relative accuracy (GAIN).

Dispersion. The effects of dispersion replicated those found by Payne, Bettman, and Johnson (1988) for all the variables except one. High dispersion led to significantly less processing, more selectivity, and more attribute-based processing.⁵ Payne, Bettman, and Johnson (1988) found that accuracy was not significantly different for high dispersion and low dispersion conditions. Thus, they concluded that the subjects in their experiment were able to adapt in ways that produced equivalent accuracy with less effort in the high dispersion condition. In contrast, the subjects in the present study were more accurate for high dispersion problems ($M = .79$ vs. $M = .67$, $F(1,2518) = 89.1$, $p < .0001$). This suggests even more strongly than the Payne et. al. results that adaptivity to problem characteristics can lend to efficient decision processing, i.e., high accuracy with relatively less effort.

Accuracy Feedback. The prediction for accuracy feedback was that such feedback would have its largest impact for problems with low dispersion. Accuracy feedback was hypothesized to lead to more normative processing (i.e., a greater amount of processing, less selectivity, more alternative-based processing, and higher relative accuracy). Hence, an accuracy feedback by dispersion interaction is predicted. We first present the main effect results for accuracy feedback and then consider the interactions.

The presence of accuracy feedback increases the number of acquisitions ($M = 30.1$ vs. $M = 22.6$, $F(1,77) = 4.4$, $p < .04$) and marginally increases the time spent on the information in the boxes ($M = 16.9$ vs. $M = 12.3$, $F(1,77) = 3.2$, $p < .08$). Hence, more processing is done with accuracy feedback.

There is some limited evidence for lower selectivity under accuracy feedback. Accuracy feedback leads to decreased variance in processing across

attributes ($M = .13$ vs. $M = .17$, $F(1,77) = 4.83$, $p < .04$). However, there is no significant effect of accuracy feedback on PTMI ($F(1,77) = 2.24$, ns) or VAR-ALTER ($F(1,77) = 1.13$, ns).

Accuracy feedback leads, as hypothesized, to relatively more alternative-based processing ($M = -.31$ vs. $M = -.55$, $F(1,77) = 4.4$, $p < .04$). However, accuracy feedback has no main effect on relative accuracy ($F(1,77) = 1.26$, ns).

While these main effects are roughly in the expected directions, our hypothesis was that the main effects would be qualified by an accuracy feedback by dispersion interaction, with accuracy feedback exhibiting stronger effects for the more difficult low dispersion problems. This hypothesis received support, as there were accuracy feedback by dispersion interactions for number of acquisitions ($F(1,2518) = 7.9$, $p < .0001$), time spent acquiring information from the boxes ($F(1,2518) = 5.2$, $p < .03$), variance in processing across attributes ($F(1,2518) = 5.0$, $p < .03$), and relative accuracy ($F(1,2518) = 14.6$, $p < .0001$). As shown in Table 2, three of these interactions have the predicted form: there is more impact of accuracy feedback for low dispersion problems than for high dispersion problems for ACQ, BOXTIME, and GAIN. For VAR-ATTRIB, the low dispersion, high dispersion condition shows the lowest selectivity, as predicted, but there is a greater effect of accuracy feedback under high dispersion. Only one variable, PATTERN, displays a main effect for accuracy feedback without the qualifying interaction with dispersion. Table 2 also shows that the interaction results for PATTERN have the hypothesized form, although they do not attain significance.

 Insert Table 2 about here

Table 2

Accuracy Feedback by Dispersion Interactions

Dispersion Accuracy Feedback	<u>Low</u>		<u>High</u>	
	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
ACQ	23.0	33.3	22.1	28.2
BOXTIME	12.8	18.7	11.8	15.1
VAR-ATTRIB	.14	.11	.20	.15
PATTERN	-.50	-.25	-.60	-.38
GAIN	.62	.72	.78	.78

Thus, the results for accuracy feedback are generally as hypothesized. Accuracy feedback leads to more normative forms of processing and improved performance for low dispersion problems. Interactions of accuracy feedback with goal and with effort feedback and goal are discussed below.

Effort Feedback. The effects of effort feedback can be described fairly simply. There were no significant main effects of effort on any of the process measures or relative accuracy. In addition, there were no significant accuracy feedback by effort feedback interactions. Importantly, and in contrast to the results for accuracy feedback, there were also no significant effort feedback by dispersion interactions.

Although this lack of results is as hypothesized, one might argue that the manipulation of effort feedback was simply inadequate. However, there were interactive effects of effort feedback with other variables; in particular, we discuss results below showing that effort feedback, accuracy feedback, and goal interact. Thus, effort feedback appears to provide little additional information to subjects beyond that provided by process feedback; however, effort feedback may have some effects on subjects' goals.

Effects of Goal. We have argued above that a goal (incentive scheme) emphasizing maximizing accuracy will lead to more normative strategies than a goal emphasizing minimizing effort. In particular, we would expect more processing, less selective processing, more alternative-based processing, and improved relative accuracy when the goal emphasizes accuracy more than effort. This pattern of results was supported, as described below.

Subjects did more processing when the goal was to maximize accuracy rather than to minimize effort. More information was acquired ($M = 31.4$ vs. $M = 22.3$, $F(1,2518) = 10.6$, $p < .002$) and more time was spent on the information in the boxes ($M = 18.1$ vs. $M = 11.3$, $F(1,2518) = 159.1$, $p < .0001$). In

addition, information acquisition was less selective under a goal of maximizing accuracy. There was proportionally less time spent on the most important attribute ($M = .37$ vs. $M = .41$, $F(1,2518) = 30.9$, $p < .0001$), less variance in processing over attributes ($M = .13$ vs. $M = .17$, $F(1,2518) = 36.9$, $p < .0001$), and less variance in processing across alternatives ($M = .08$ vs. $M = .09$, $F(1,2513) = 9.5$, $p < .003$). Finally, processing was more alternative-based when the goal was to maximize accuracy ($M = -.35$ vs. $M = -.50$, $F(1,2466) = 65.2$, $p < .0001$). Note that the fact that there was greater processing by attribute when the goal was to minimize effort supports the suggestion of Russo and Doshier (1983) that attribute-based processing is cognitively easier.

Processing does become more extensive, less selective, and more alternative-based when the goal is to maximize accuracy, as hypothesized. Such processing, more consistent with normative strategies, also leads to better performance. When the goal is to maximize accuracy, subjects attain greater relative accuracy levels ($M = .75$ vs. $M = .70$, $F(1,2518) = 19.2$, $p < .0001$).

The fact that goal affects both processing measures and accuracy raises the issue of whether the processing changes mediate the effect of goal on accuracy. To demonstrate such mediation, three relationships must be established (Baron & Kenny, 1986): 1) that the goal manipulation significantly affects processing; 2) that processing measures are significantly related to accuracy; and 3) the effect of goal on accuracy is weakened or eliminated if processing measures are used as covariates.

The results reported above show that goal significantly affects several measures of processing: amount of information acquired, time spent on information in the boxes, time spent on the most important attribute, variance in processing over attributes and alternatives, and the pattern of processing.

Hence, we next examined whether each of these processing measures was significantly related to accuracy over all trials for all subjects.⁶ We computed the correlation between accuracy and each of these process measures. The correlations were significant for number of acquisitions ($r = .12$, $p < .0001$), time spent on information in the boxes ($r = .10$, $p < .0001$), variance in processing over alternatives ($r = -.05$, $p < .01$), and the pattern of processing ($r = .14$, $p < .0001$). The correlations were not significant for variance in processing over attributes ($r = -.02$) or proportion of time spent on the most important attribute ($r = .003$). Hence, the first four variables above meet the second test for mediation, while the latter two do not.

Finally, we examined the third criterion for mediation, the effect of goal on accuracy with processing variables included as covariates. Since the amount of information acquired and the time spent on information in the boxes were highly collinear ($r = .88$), we only used time spent on information in the boxes, variance in processing over alternatives, and pattern of processing as covariates. With these covariates included, the effect of goal on accuracy remains significant ($F(1,2371) = 8.45$, $p < .004$). However, this effect is weakened, as the F value without the covariates was 19.2. The three covariates are all significant or approach significance (time spent on information in the boxes, $F(1,2371) = 3.53$, $p < .06$; variance in processing over alternatives, $F(1,2371) = 6.95$, $p < .01$; and pattern of processing, $F(1,2371) = 8.04$, $p < .005$). Hence, these three variables meet the three tests for mediation. However, since the effect of goal on accuracy remains significant, the impact of goal on accuracy is not completely mediated by changes in the processing variables investigated.

Interactions Between Feedback and Goal. Our final hypothesis stated that accuracy feedback and effort feedback will interact with the decision

maker's goal to determine processing and performance. We argued that feedback can also have motivational effects. When the goal is to maximize accuracy, both accuracy feedback and effort feedback may lead to more normative processing and better performance. When the goal is to minimize effort, however, we argued that effort feedback may lead to more heuristic processing and reduced performance and that accuracy feedback may have little impact. We examine these predictions initially by considering the two-way interactions of accuracy feedback with goal and effort feedback with goal. Then the three-way interaction of accuracy feedback, effort feedback, and goal is described.

The significant two-way interactions of accuracy feedback and goal are summarized in Table 3 for the number of acquisitions ($F(1,2518) = 10.6, p < .002$), time spent on the information in the boxes ($F(1,2518) = 8.5, p < .004$), proportion of time spent on the most important attribute ($F(1,2518) = 22.3, p < .0001$), and variation in processing across attributes ($F(1,2518) = 22.6, p < .0001$). The interactions did not reach significance for the other dependent variables.

 Insert Table 3 about here

The form of these interactions is as predicted. Note that accuracy feedback leads to more normative processing to a greater extent for a goal of maximizing accuracy than for a goal of minimizing effort. However, contrary to the hypothesis, there is no interaction of accuracy feedback and goal for relative accuracy. Performance is improved equally by accuracy feedback regardless of the goal.

The significant two-way interactions of effort feedback and goal are presented in Table 4 for time spent on the information in the boxes ($F(1,2518) = 3.0, p < .09$), proportion of time spent on the most important attribute

Table 3

Accuracy Feedback by Goal Interactions

Goal Accuracy Feedback	<u>Minimize Effort</u>		<u>Maximize Accuracy</u>	
	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
ACQ	19.3	25.2	25.9	36.4
BOXTIME	9.8	12.8	14.8	21.0
PTMI	.41	.40	.40	.33
VAR-ATTRIB	.17	.15	.17	.11

($F(1,2518) = 5.1, p < .03$), and relative accuracy ($F(1,2518) = 4.8, p < .03$). These interactions do not present a clear picture. As hypothesized, effort feedback leads to decreased relative accuracy when the goal is to minimize effort and increased relative accuracy when the goal is to maximize accuracy. Also as hypothesized, effort feedback leads to a greater proportion of time on the most important attribute when the goal is to minimize effort and a smaller proportion when the goal is to maximize accuracy. Contrary to the hypothesis, however, effort feedback leads to less time spent on information in the boxes when maximizing accuracy is the goal and has very little impact on BOXTIME when the goal is minimizing effort.

 Insert Table 4 about here

When the three-way interactions of accuracy feedback, effort feedback, and goal are examined, a more complex picture than that originally hypothesized emerges. There are significant three-way interactions for number of acquisitions ($F(1,2518) = 3.6, p < .06$) and relative accuracy ($F(1,2518) = 8.6, p < .004$). These two interactions are shown in Table 5. When no accuracy feedback is available, effort feedback appears to increase acquisitions and relative accuracy, regardless of goal. When accuracy feedback is available, however, effort feedback reduces both acquisitions and performance when the goal is to minimize effort. When the goal is to maximize accuracy, effort feedback reduces acquisitions, but not performance, in the presence of accuracy feedback.

 Insert Table 5 about here

Discussion

Table 4

Effort Feedback by Goal Interactions

Goal Effort Feedback	<u>Minimize Effort</u>		<u>Maximize Accuracy</u>	
	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
BOXTIME	11.6	11.1	19.3	16.9
PTMI	.40	.42	.37	.36
GAIN	.72	.68	.74	.76

Table 5

Accuracy Feedback by Effort Feedback by Goal Interactions

Goal	<u>Minimize Effort</u>				<u>Maximize Accuracy</u>			
	<u>No</u>		<u>Yes</u>		<u>No</u>		<u>Yes</u>	
Accuracy Feedback	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>	<u>No</u>	<u>Yes</u>
Effort Feedback								
ACQ	16.1	22.1	27.2	22.9	24.7	26.9	38.0	34.6
GAIN	.66	.70	.77	.67	.71	.73	.77	.79

Research has shown that the same individual will often use a variety of strategies to make a decision, contingent on task demands (Payne, 1982). A key question for decision research today is to better understand the selection of decision strategies.

This paper has examined the roles of effort and accuracy feedback on decision processes and the role of goals that emphasize accuracy or effort on strategy selection. The results show that feedback on the accuracy of decisions leads to more normative-like processing of information and improved performance. However, the role of accuracy feedback is much greater for certain types of decision problems. In particular, when faced with decision problems involving low dispersion in the weights of the attributes, accuracy feedback had a large effect on decision processes. In contrast, accuracy feedback had almost no impact on the behavior of subjects faced with problems involving high dispersion in weights. Thus, accuracy feedback appeared to have its greatest impact when the decision problems were more difficult. For such problems, process feedback and general knowledge of what makes for a "good" strategy are less applicable and feedback hence becomes more necessary.

Explicit effort feedback, on the other hand, had no impact on processing or performance regardless of the dispersion in weights. In general, the idea that people are able to generate fairly adequate notions about their own effort levels through process feedback was supported. The only area in which effort feedback did appear to have an impact was in terms of interaction with goal. That relationship will be discussed after we have reviewed the effects of goals (incentives) on decision processing.

The effort/accuracy view of strategy selection implies that people should utilize strategies that provide greater accuracy (often at the cost of greater effort) when the incentives associated with accuracy are increased.

However, as pointed out by several authors (e.g., Tversky and Kahneman, 1986; Wright and Aboul-Ezz, 1986), incentives sometimes enhance performance and at other times have no effect. Payne, Bettman, and Johnson (In press) discuss these ambiguous research results in terms of the common distinction between working harder versus working smarter (see also Einhorn & Hogarth, 1986; Tversky & Kahneman, 1986). That is, incentives may cause individuals to work harder, but not necessarily smarter.

Another contributing factor to the ambiguity in results may be procedural. Often the procedure used in studies of incentive effects has been to simply increase the payoffs associated with good judgments. In the present study, the possible effects of incentives on the effort/accuracy tradeoff associated with various strategies were more directly manipulated by explicitly emphasizing either a goal of maximizing accuracy relative to effort or minimizing effort relative to accuracy. The results demonstrated that the goal of maximizing accuracy led to more processing of information, less selectivity in processing, more alternative-based processing of information, and improved performance. These results provide the clearest evidence available to date for the effects of differences in goals on detailed process tracing measures of decision strategies (i.e., Billings and Scherer, 1988, find relatively weak evidence for effects of decision importance on processing; see also Ford, Schemitt, Schechtman, Halts and Doherty, 1989, pp. 101-102, for a similar appraisal). To summarize, when the incentives were structured to emphasize the goal of accuracy more than effort, we found a shift in strategies in the direction predicted by the effort/accuracy framework.

As mentioned above, there were several interactions observed between the presence of effort feedback and goals. Overall, it appeared that effort

feedback led to decreased accuracy when the goal was to minimize effort and to increased accuracy when the goal was to maximize accuracy. That is, effort feedback appeared to amplify the effects of goal. However, the picture was less clear when the three-way interactions of goal, effort feedback, and accuracy feedback were considered. In that case, the overall pattern of results departed from that hypothesized in several respects: 1) Effort feedback only decreased acquisitions and performance for a minimizing effort goal when accuracy feedback was present; and 2) Effort feedback decreased acquisitions for a goal of maximizing accuracy when accuracy feedback was present. These patterns are intriguing and lead to some admittedly speculative interpretations of these discrepant findings: a) When no accuracy feedback is available, subjects may use effort feedback to help them gauge the reasonableness of their decision processes (see Yates & Kulik, 1977). This could hold even for a minimizing effort goal if subjects have some minimal level of reasonableness they feel their decision processes should meet. Recall from the description of the performance index above that accuracy receives some weight even when the goal is to minimize effort. Hence, effort feedback may lead to increased processing and performance; b) Subjects may achieve higher performance when they have accuracy feedback but no effort feedback even for the minimize effort goal because they can use the accuracy feedback and are not fully aware that they are expending somewhat more effort in doing so. When effort feedback is available, subjects reduce their effort, no longer rely on accuracy feedback as much, and their performance suffers; and c) With both accuracy feedback and effort feedback present, subjects may learn to achieve the same levels of performance with somewhat less effort. That is, the presence of both types of feedback may allow subjects to become more efficient. Such efficiency would be most likely to develop when the goal

is to maximize accuracy. When the goal is to minimize effort, subjects may not attempt to use accuracy feedback as fully when effort feedback is also available, as noted above.

In summary, the present study has shown that accuracy feedback and manipulation of the relative emphasis on maximization of accuracy versus minimization of effort affect strategy selection in ways consistent with a general effort/accuracy framework. However, there are complex interactive relationships between various types of feedback and alternative goal structures which remain unclear. Further research investigating how incentives, feedback, and the structure of decision tasks combine to affect strategy selection and performance can make a major contribution to our understanding of effort/accuracy approaches to decision making.

Footnotes

This paper is based in part on research conducted by Elizabeth H. Creyer in fulfillment of the requirements for her Ph.D. degree at Duke University.

¹A four outcome gamble with a low degree of dispersion might have probabilities of .30, .20, .22, and .28 for the four outcomes, respectively. In contrast, a gamble with a high degree of dispersion might have probabilities such as .68, .12, .05, and .15 for the four outcomes. This variable was included because Thorngate (1980) had suggested the possibility that probability information may be relatively unimportant in making accurate risky choices (see also Beach, 1983).

² In a study with 32 subjects exposed to decision problems varying on dispersion, presence or absence of dominated alternatives, and incentives, subjects rated low dispersion problems more difficult than high dispersion choices (means of 4.93 vs. 3.91 on a scale where 0 = not at all difficult and 10 = extremely difficult, $p < .0001$). In addition, the subjects stated that they were more confident about their choices for low dispersion problems than for high dispersion problems (means of 7.36 vs. 6.54 on a scale where 0 = not at all confident and 10 = extremely confident, $p < .0001$).

³ In order to demonstrate that subjects with effort feedback did not perceive greater time pressure, after they completed all 32 choices subjects were asked to indicate on a 1 (low) to 7 (high) scale how much time pressure they experienced. There were no significant effects of effort feedback or accuracy feedback on this measure.

⁴ These means, and the univariate analyses of variance reported below, are based upon the total number of cases for each variable. The multivariate analysis of variance eliminates any observation missing any variable, so there

are fewer cases for the multivariate analysis. The means are virtually identical for the two cases.

⁵ High dispersion led to fewer acquisitions (ACQ) ($M = 25.3$ vs. $M = 28.4$, $F(1,2518) = 20.2$, $p < .0001$), less BOXTIME ($M = 13.5$ vs. $M = 15.9$, $F(1,2518) = 19.5$, $p < .0001$), more focus on the most important dimension (PTMI) ($M = .42$ vs. $M = .36$, $F(1,2518) = 60.0$, $P < .0001$), higher selectivity for attributes (VAR-ATTRIB) ($M = .17$ vs. $M = .12$, $F(1, 2518) = 94.0$, $p < .0001$), and more attribute-based processing (lower values of PATTERN) ($M = -.48$ vs. $M = -.37$, $F(1,2466) = 36.6$, $p < .0001$). The effect of dispersion on variance in processing across alternatives (VAR-ALTER) was not significant ($F(1,2513) = 2.65$, ns).

⁶ The number of trials available for these correlations ranged from 2467 to 2519, depending upon the number of cases with missing data for each variable.

References

- Abelson, R. P. & Levi, A. (1985). Decision making and decision theory. In G. Lindzey & E. Aronson (Eds.), The Handbook of Social Psychology: Vol. 1. New York, Random House.
- Anzai, Y., & Simon, H.A. (1979). The theory of learning by doing. Psychological Review, 86, 124-140.
- Baron, R.M., & Kenny, D.A. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. Journal of Personality and Social Psychology, 51, 1173-1182.
- Beach, L. R. (1983). Muddling through: A response to Yates and Goldstein. Organizational Behavior and Human Performance, 31, 47-53.
- Beach, L. R., & Mitchell, T. R. (1978). A contingency model for the selection of decision strategies. Academy of Management Review, 3, 439-449.
- Billings, R.S., & Scherer, L.M. (1988). The effects of response mode and importance in decision making strategies; Judgment versus choice. Organizational Behavior and Human Decision Process, 41, 1-19.
- Einhorn, H. J., & Hogarth, R. M. (1981). Behavioral decision theory: Processes of judgment and choice. Annual Review of Psychology, 32, 53-88.
- Einhorn, H.J., & Hogarth, R.M. (1986). Decision making under ambiguity. Journal of Business, 59, 5225-5250.
- Hammond, K.R. (1989). A theoretically based review of theory and research in judgment and decision making. (Report No. 260). Boulder, CO: Center for Research on Judgment and Policy, Institute of Cognitive Science, University of Colorado.
- Ford, J.K., Schmitt, N., Schechtman, S.L., Hults, B.M., & Doherty, M.L. (1989). Process tracing methods: Contributions, problems, and neglected

research questions. Organizational Behavior and Human Decision Processes, 43, 75-117.

Johnson, E. J., & Payne, J. W. (1985). Effort and accuracy in choice. Management Science, 31, 395-414.

Johnson, E. J., Payne, J. W., Schkade, D. A., & Bettman, J. R. (1986). Monitoring information processing and decisions: The mouselab system. Unpublished manuscript, Center for Decision Studies, Fuqua School of Business, Duke University.

Klayman, J. (1983). Analysis of predecisional information search patterns. In P. C. Humphreys, O. Svenson, & A. Vari (Eds.), Analyzing and aiding decision processes. Amsterdam: North Holland.

Payne, J. W. (1976). Task complexity and contingent processing in decision making: An information search and protocol analysis. Organizational Behavior and Human Performance, 16, 366-387.

Payne, J. W. (1982). Contingent decision behavior. Psychological Bulletin, 92, 382-402.

Payne, J. W., Bettman, J. R., & Johnson, E. J. (1988). Adaptive strategy selection in decision making. Journal of Experimental Psychology: Learning, Memory, and Cognition, 14, 534-552.

Payne, J.W., Bettman, J.R., & Johnson, E.J. (In press). The adaptive decision maker: Effort and Accuracy in Choice. In R. Hogarth (ed.), Insights in decision making: Theory and applications-A tribute to Hillel J. Einhorn. Chicago: University of Chicago Press.

Reder, L.M. (1987). Strategy selection in question answering. Cognitive Psychology, 19, 90-138.

- Russo, J. E., & Doshier, B. A. (1983). Strategies for multi-attribute binary choice. Journal of Experimental Psychology: Learning, Memory, and Cognition, 9, 676-696.
- Svenson, O. (1979). Process descriptions of decision making. Organizational Behavior and Human Performance, 23, 86-112.
- Tetlock, P. E., & Levi, A. (1982). Attribution bias: On the inconclusiveness of the cognition-motivation debate. Journal of Experimental Social Psychology, 18, 68-88.
- Thorngate, W. (1980). Efficient decision heuristics. Behavioral Science, 25, 219-225.
- Tversky, A. (1969). Intransitivity of preferences. Psychological Review, 76, 31-48.
- Tversky, A. (1972). Elimination by aspects: A theory of choice. Psychological Review, 79, 281-299.
- Tversky, A., & Kahneman, D. (1986). Rational choice and the framing of decisions. Journal of Business, 59, 5251-5278.
- Wright, W.F., & Aboul-Ezz, M.E. (1988). Effects of extrinsic incentives on the quality of frequency assessments. Organizational Behavior and Human Decision Processes, 41, 143-152.
- Yates, J.F., & Kulick, R.M. (1977). Effort control and judgments. Organizational Behavior and Human Performance, 20, 54-65.
- Zakay, D., & Wooller, S. (1984). Time pressure, training and decision effectiveness. Ergonomics, 27, 273-284.